Health-Based 24-Hour Air Monitoring Comparison Value (AMCV) for Acrolein in Ambient Air: Comparison to Air Monitoring Data Collected in Texas

A. Jenkins, *Toxicology Division, Texas Commission on Environmental Quality, Austin, TX*

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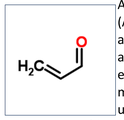
Abstract

Acrolein is of national and state interest because it is ubiquitous, is difficult to analyze in ambient air, and concentrations causing eye and respiratory irritation are low. In 2011, a follow-up special monitoring project for acrolein was conducted by the USEPA at a school near a building products manufacturing facility in Texas. Ten 24-hour (hr) ambient air samples were collected in canisters downwind of a facility known to emit acrolein and analyzed using an improved method. The additional monitoring project was done in response to finding that acrolein canister monitoring results can be affected by the canister cleaning method and the calibration gas standards. The Texas Commission on Environmental Quality (TCEQ) has previously derived 1-hr and chronic health-protective AMCVs for acrolein in order to evaluate air monitoring data. In order to evaluate the 24-hr data collected at the school and at two other permanent monitoring sites in Texas, the TCEQ has developed a proposed 24-hr AMCV to better evaluate any potential for adverse health effects. Acrolein's toxicity is mainly concentration dependent and levels causing adverse effects are very similar in humans and animals. The same rat study used to develop the chronic AMCV was selected as the critical study for derivation of the 24-hr AMCV since interim histopathology was performed after various exposure durations (e.g., 6 hr/day for 4, 14, 30, and 65 days) which encompassed the 24-hr duration of interest. A no-observed-adverse-effect level of 200 ppb was identified from the key study for all exposure durations based on the absence of nasal epithelial hyperplasia. Based on a mode-of-action analysis, no duration adjustment was necessary. After correcting for animal-to-human dosimetric differences, the 24-hr human equivalent point of departure was 37.4 ppb. Total uncertainty factors of 30 were applied to calculate the 24-hr AMCV of 1.2 ppb. In comparison, the 1-hr AMCV for acrolein is 4.8 ppb and its chronic AMCV is 0.22 ppb. No concentrations exceeding the 24-hr AMCV have been measured in canister samples using the improved canister method.

Introduction



Acrolein (C3H4O) is a clear or yellow liquid with a piercing, disagreeable "acrid" odor (ATSDR 2007). It is water soluble, volatile, and highly reactive. Human exposure to acrolein is primarily through tobacco smoke, gasoline and diesel exhaust, structural and forest fires, and partially combusted animal fats and vegetable oils (Beauchamp et al. 1985). It is used as an intermediate in the production of acrylic acid, glycerine, methionine, glutaraldehyde, and other organic chemicals (HSDB 2005). It is also used as an herbicide for control of vegetation in irrigation canals and as a biocide in water pumped into injection wells associated with petroleum production (USEPA 2008). Inhalation of acrolein vapors can cause respiratory irritation, eye and nose irritation, and at higher levels, severe respiratory tract irritation and lacrimation (TCEQ 2010).

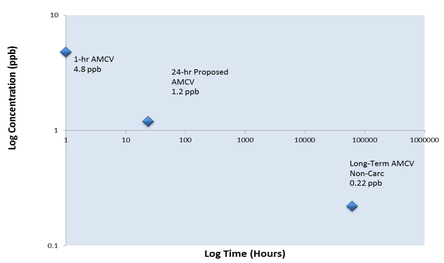
The TCEQ has not historically developed 24-hr, health-based AMCVs for comparison to individual 24-h data from its monitoring network. The development of 24-hr AMCVs is necessary to accurately evaluate individual monitored data collected over 24 hrs.

Acrolein was a key chemical monitored for a 24-hr period by the USEPA at a school in Texas and is ubiquitous in ambient air. Acrolein is a chemical for which a proposed 24-hr, health-protective AMCV has been developed.

Acrolein AMCVs

To ensure that the general public in Texas is protected against the potential effects from acrolein exposure, the TCEQ has developed a series of inhalation toxicity factors, e.g., AMCVs and effects screening levels (ESLs), for effects evaluation using up-to-date toxicity information and TCEQ Guidelines to Develop Toxicity Factors (TCEQ 2012). AMCVs, similar to United States Environmental Protection Agency (USEPA) reference concentrations (RfCs) or California EPA's reference exposure levels (RELs), are used to evaluate short-term and long-term ambient air monitoring data. Figure 1 shows the TCEQ's 1-hr and long-term AMCVs for acrolein of 4.8 ppb and 0.22 ppb, respectively (TCEQ 2010). In addition, Figure 1 shows the proposed 24-hr AMCV of 1.2 ppb.

Figure 1. Acrolein: 1-Hr, 24-Hr Proposed, and Long-Term AMCVs



Development of 24-Hour AMCV

General steps discussed below for derivation of the proposed 24-hr AMCV for acrolein include: identification of a point of departure (POD) for the critical effect(s) based on review of dose-response data for relevant toxicity endpoints, consideration of an exposure duration adjustment, dosimetric adjustments of concentrations from animal studies to concentrations relevant to humans, selection and application of applicable uncertainty factors, and derivation of the proposed 24-hr AMCV value (Table 1)

Critical Study

Four studies were evaluated for use in deriving the 24-hr AMCV (Weber-Tschopp et al. 1977, Dorman et al. 2008, Cassee et al. 1996, and Roemer et al. 1993). The Dorman et al. 2008 study was chosen as the key study because it investigated both duration and concentration effects and included several exposure groups and exposure durations. Dorman et al. (2008) exposed male F344 rats (whole-body exposure) to concentrations of 0.02, 0.06, 0.2, 0.6, or 1.8 ppm acrolein for 6 hr/day for 4 days. The POD from the key study was the NOAEL of 0.2 ppm (absence of critical effect - nasal respiratory epithelial hyperplasia). The effects were not amenable to benchmark dose modeling.

Duration Adjustment

No duration adjustment was performed, as adverse effects of acrolein are mainly concentration dependent. Acrolein is a highly reactive aldehyde that is strongly irritating to mucous membranes, especially the eyes and upper respiratory tract (TCEQ 2010). The health effects produced by acrolein are respiratory tract effects in the extrathoracic region of the respiratory tract.

Dosimetric Adjustments

Dosimetric adjustments were performed as a Category 1 gas and as such, the POD was multiplied by the regional gas dose ratio (RGDRr) of 0.187. The RGDRr is the ratio of regional gas dose in rats to that of humans. The resulting POD_{HEC} was 0.0374 ppm.

Uncertainty Factor

Total uncertainty factors (UF) of 30 (interspecies UF of 3, intraspecies UF of 10, database UF of 1) was applied to the POD_{HEC} to result in the proposed 24-hr AMCV of 0.0012 ppm (1.2 ppb).

Table 1. Derivation of the Proposed 24-Hour AMCV for Acrolein

Key Study	**Dorman et al. (2008)**
Study Population	360 adult Fischer-344 rats (12 rats/ exposure concentration/time point)
Exposure Method	Discontinuous whole body at 0, 0.02, 0.06, 0.20, 0.6, or 1.8 ppm
Exposure Duration	6 h/day for 4 days
Critical Effects	Absence of nasal epithelial hyperplasia
Duration extrapolation	No adjustment to 24 hr. Concentration dependent; 13-week NOAEL was also 0.2 ppm.
NOAEL	0.2 ppm
POD_{HEC}	0.0374 ppm (37.4 ppb)
Total UFs	30
Interspecies UF_A	3
Intraspecies UF_H	10
Incomplete Database UF_D	1
Proposed 24-Hr AMCV	1.2 ppb

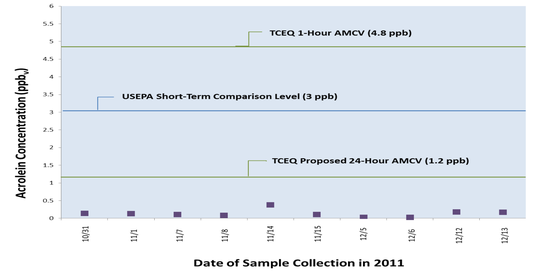
Comparison of 24-Hour AMCV to Air Data

USEPA selected six schools in Texas for monitoring as part of a nationwide air toxics monitoring initiative to measure levels of air toxics at schools. One of the Texas schools was located in Diboll, TX, and was selected for monitoring because it was located near a lumber, fiberboard and particle board manufacturing complex which is a source of air toxics emissions (including acrolein). Air monitoring was initially conducted at Temple Elementary School from October 28, 2009 to March 8, 2010, to assess concentrations of acrolein and volatile organic compounds (VOCs) in the air. EPA was not able to use the original acrolein data due to concerns about the consistency and reliability of monitoring results of acrolein.

Since the original monitoring project began in Fall 2009, EPA improved the accuracy of acrolein sampling and conducted additional monitoring for acrolein and VOCs from October 31, 2011 to December 13, 2011. Ten, 24-hr canister samples were collected and analyzed for acrolein and other VOCs. The USEPA compared 24-hour measured concentrations of acrolein to the USEPA Short-Term Comparison Level for this project of 3 ppb (the same level as the Agency for Toxic Substances and Disease Registry's acute Minimal Risk Level (MRL)). In addition, the TCEQ compared the measured levels of acrolein from the canister samples to the proposed 24-hr AMCV for acrolein of 1.2 ppb.

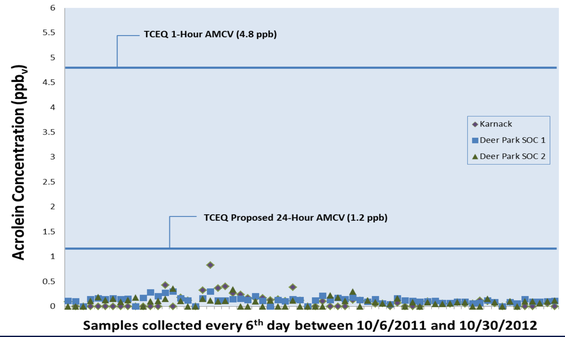
- No concentrations exceeding the proposed 24-hr AMCV or the USEPA's short-term comparison level were measured at Temple Elementary School (Figure 1).
- Measured concentrations of acrolein were similar to those typically measured in most location in the US.
- USEPA will not extend air toxics monitoring at Temple Elementary School.

Figure 2. 24-Hr Acrolein Canister Data Collected at Texas Elementary School with Comparison Levels



In addition to the USEPA's special school monitoring project, there are two sites in TX which collect 24-hr canister samples of ambient air approximately every sixth day, including acrolein. Those sites are located in Karnack (in East Texas) and in Deer Park (near Houston). A comparison of the proposed 24-hr AMCV for acrolein to the improved ("verified") acrolein 24-hr data was conducted. Verified acrolein data are those data that have been collected and analyzed using USEPA's improved acrolein analysis methodology. Concentrations of acrolein collected at the sites using the improved sampling method implemented in October 2011 have not exceeded the 24-hr AMCV (Figure 3).

Figure 3. 24-Hr Acrolein Canister Data Collected at Sites in Texas with Comparison Values



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